# PROJECT–BASED PRODUCT DEVELOPMENT EDUCATION

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**ABSTRACT**
The primary goal of innovative design is to develop cost and functionally effective products that meet the demands of the market. Product development is a very complex process. At the Faculty of mechanical engineering, University of Maribor, the students are acquainted with this process in the third year of their study at the subject Fundaments and Methods of Engineering Design. The mechanical engineering design education system includes many subjects, which give to the students a lot of basic knowledge. Usually, the students study each of the subjects separately, and have thus difficulties to build the complex knowledge scheme by themselves. Besides, the traditional way of the study is theoretical and individual. Consequently, using their knowledge the students do not know how to deal with real-life problems, especially when they start to work in practice. In this respect the aim of our subject is not only to present the complexity of design, but also to simulate the product real-life development process and to prepare the students for their future work in practice through the project-based teamwork. In this paper, our experiences gained in the project-based design education process will be presented along with some students' achievements.

*Keywords: Mechanical engineering design, methods, teamwork*

## 1 INTRODUCTION

Designing new products is complex and comprehensive task that has a very important role in nowadays high-tech technology, where only optimal solutions/products can win the game on the market. Decisions made in design process have a significant influence on the competitiveness of the future product on the market. Therefore it is important how the methods and fundamental principles of design are presented to the students and how much the students become aware of design process and its complexity. From the beginning of the 1990's, at the Faculty of mechanical engineering, University of Maribor the practical part of the curriculum at the subject named Fundaments and Methods of Engineering Design is based on the project-oriented teamwork.

There are thee important aspects of project-based product development education. First of all, the students have to develop a novel solution for a certain problem. They need to work in a team, and at the end of the project, they also have to present their work to the teachers and to their colleagues. It is very important that they learn how to present and defend their final solution with convincing arguments.

Engineering study is still rather too much individual. The students are not used to work in a group. At the start, they act very quietly. With some encouragement and careful selection of the team leader and positive team surroundings, the work is set free and

becomes creative, while the members of the team slowly gain necessary competence. Through a step-by-step project elaboration, the students realise spontaneously how to use the knowledge from all other subjects and also how to acquire some new knowledge needed to perform the project. Slowly they become self-confident. At the end of the project, they feel important and satisfied. They are proud of their achievement and ability to perform such a project applying the knowledge from previous courses.
A short review of project-based product development education process based on teamwork will be presented in this paper. The presentation will be supplemented with some students' achievements and the lecturers' experiences.

## 2 WHY PROJECT-BASED PRODUCT DEVELOPMENT EDUCATION?

There is a well-known Chinese proverb saying: "Tell me and I will forget. Show me and I may remember. Involve me and I will understand. Take one step back and I will act." Considering the last statement, autonomous groups of students should be involved into design education process. Furthermore, the project-based product development education confirms the additional statement [1]: "Do all four and I will become competent".
Performing project-based product development the students can use the variety of knowledge, acquired through the whole mechanical engineering educational process. However, the aim of our subject is not only to teach them how to perform product development process, but also to confront them with the teamwork. Teamwork is still too spare at the universities [2], but it is inevitable in nowadays practice and also for project-based learning. Although project-oriented learning mode enables better understanding, it is also not so frequent at high level of education [3]. We use this approach to ascertain if and how the students are capable to solve a real-life problem. Furthermore, our aim is also to stimulate the students' inventiveness, creativity [4] and self-confidence. The whole design process is simulated through the practical teamwork on project elaboration. The role of the lecturer is to guide the students how to acquire and use the knowledge and their own abilities to realize the project.
Through project-based exercises, the students become aware of the modern design methods and tools that increase creativity and productivity, and can help to improve the quality of the new products. Generally, the project elaboration of the students is successful and the students are satisfied with the course of exercises. Often they even present the knowledge and results that are expected neither by themselves nor by the lecturer [5], as their creativeness and innovativeness are sometimes not so obvious.

## 3 WHAT KIND OF PROJECT?

The real-life design process can be well simulated only with the real-life project/problem, which is not adequately solved yet. If the problem is already solved, the students are handicapped with the existing solution and they are persuaded that they cannot find the better solution. Usually, it is very difficult to motivate them to improve the subsistent result.
In our case, the students are welcome to play an active role in the project definition. They are encouraged by the lecturer to analyse the wishes, the needs or the requirements of the market and to find the suitable product/project, which could in real-life ensure them a job and economical survival. Sometimes, the students are not able to define the problem by themselves. They often have too many ideas, but they do not like any of them. Alternatively, they think "we are only students" and they prefer to get the project definition. It is not easy for the lecturer to define each year a number of new projects.

Contacts with the people from practice, who are familiar with the real-life problems, can be very helpful. The project definition can be determined very common and unassuming or very exact with specification of all kind of demands. A simple definition enables the students to fit the project to their wishes and knowledge or to the eventual economic success. Typical projects include home appliances, sport and gardening equipment, special tools, etc. This paper includes figures showing three different projects, as follows: cable installation device (Fig. 1 and 2), ski trail cutter (Fig. 3 – left), and cattle feeder (Fig. 3 – right). All three projects presented were defined by the students.

## 4 WHY GROUP WORK AND WHAT KIND OF GROUP IS IDEAL?

The complex nature of modern industry requires teamwork. In modern world, an individual cannot understand all new things, which emerge all the time. It is more and more evident, that the designer should be a specialist for a specific technical area and be prepared to collaborate with other specialists and use their knowledge. In present time, the time of computers and people in hurry, the society of the individualists is predominated. People are usually not used to communicate and discuss fluently about their work or life.

Furthermore, it is a fact that the group work has many advantages. The solution of the problem should be found by all members of the group. Each member has own ideas about the solution. Nevertheless, all members should discuss about their ideas and decide which idea is the most promising. The member should present his or her opinion, and it is constructively added or corrected by other members. In such a way, they extend the task comprehension and their experiences. The personality, knowledge, and experiences of the members are different and each can contribute a significant part.

Design work is very complex and can be successful if people with different education and experiences perform it together. In our case, the group is not multidisciplinary, as it is combined only by the students of a mechanical engineering. However, they still possess different knowledge and skills. The groups involve from five to seven students. Less then five students are not enough, because some methods, for example the method 635 (6 persons give 3 ideas in 5 minutes), cannot be performed effectively. On the other hand, more then seven students in a group are too much and give to someone an opportunity to hide in it [6]. The group from five to seven students can work successfully even when someone from the group is missing unexpectedly.

The groups are appointed by the lecturer. The students with some objective reason are allowed to swap their place in the group with someone from the other group, but it does not happen very often. In this way, the exclusive groups of friends or good students are prevented. From the experiences, these kinds of groups are not as efficient as one would expect. The simulation of design process by groups of students can be much more successful if every group has at least one good student. Sometimes he or she become a group leader, who co-ordinates the group work under the supervision of the lecturer.

Some groups perform very well without a group leader. The others need someone who will share the work, pay attention to the work that needs to be done, encourage the group to work and reach the deadline, and take care for all documentation. It can happen that someone wants to dominate and rule the group, but usually the other members do not allow it. More serious problem can arise, when the members of the group think that they should always consider the opinion of their leader or someone, who is better student and supposes to know everything better then they do. In this situation, the role of the lecturer is very important. The lecturer should encourage "frightened" students by pointing out their good ideas and in this way help them to become more self-confidence.

## 5 PROJECT-BASED PRODUCT DEVELOPMENT PROCESS

The project-based exercises are divided in two parts. The first part, the presentation of some previous students' works, together with explanation and demonstration, seems to be less interesting for the students. Moreover, the students are somehow even surprised what they are expected to do. However, the second part, the actual simulation of design processes for the new products, performed in small groups of students is more interesting for them. It takes about three quarter of all the time available for the exercises, which is only twenty-five hours. Because of this, much of the work needs to be done at home to conclude the project and to prepare the final presentation. In most of the cases, the students spend at least another twenty hours or even more for successful elaboration of the project. Some of the work, like writing the text or making some figures and models, can be done in smaller groups or even individually, while some other tasks, like preparing the presentation, require the presence of all team members.

Through the project-work the students realise the importance of design process and try to apply the strategy for engineering design. The education design process at our faculty is based on the ideas of Pahl and Beitz [7] laid dawn in VDI Guideline 2222 [8]. Therefore the project work follows the design process, which is split into four phases: clarification of the task, conceptual design, embodiment design, and detail design. These four phases are like "red-line" through the design process. Notwithstanding, the group work is always different, because each group is represented by different personalities and a specific problem/project. Moreover, two groups with the same project act differently, especially if one does not know about the other. The groups operate under supervision of the lecturer. The lecturer role is to guide the students through design process steps and to control the expected extent of each step.

In the first phase, the project is defined by the students or the lecturer. After the project definition, the students need to clarify the task. Then they ascertain what is already known and collect as many data as possible. On base of collected information, they draw up the detail design specification of the project – list of requirements.

After the problem specification, the groups start the second phase – the conceptual design, looking for as many as possible solution variants for the project (Fig. 1).

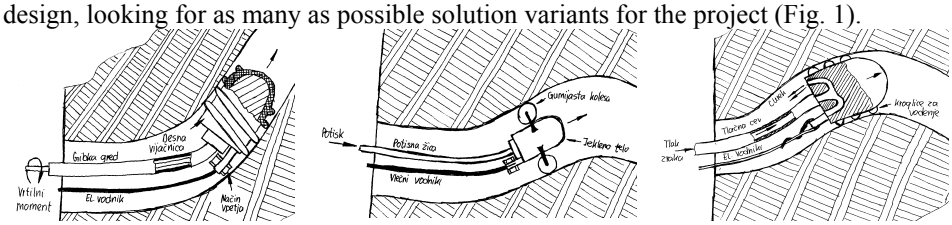


*Figure 1 Example of three project variant solutions for the cable installation device*

First, the students indicate an overall function. Because of the project complexity, they divide the main function into sub-functions and start searching the solution principles for the all sub-functions. It can be very time consuming task, especially because we expect creativity and originality. It is pointed out that various solutions of the same problem are possible. Many aids and methods are used in searching for solutions. The conventional methods, like literature search, analysis of nature systems and existing technical systems, analogies, measurements, and model tests, are complemented with methods of intuitive bias. The intuitive methods, such as brainstorming, method 635, method of dialog, and Delphi or iterative method, are suitable for the group work and generate the widest possible range of ideas. The number of different solution principles

and the combination of them assures several solution variants of the project (Fig. 1). The optimal or the most promising solution variant (Fig. 2) is chosen after the evaluation of all variants derived in the previous step. The actual evaluation criteria (technical and economical) are defined by the students.

*Figure 2 Example of chosen variant solution for the cable installation device*

The elaboration of some concept variants and the selection of the best solution concept are the most important part of design process. During the embodiment and detail design phases, it is extremely difficult or impossible to correct fundamental shortcomings of the concept solution. Because of this, the students are recommended to take more time for this part of design process and most of the groups meetings with the lecturer are meant for this phase of design.
The selected variant of the project concept presents the base for the next two phases. In the embodiment design phase the students determine the design layout and the design forms. The project documentation is the final result of the last phase - detail design. At the end of design exercises, the students usually do not finish their project elaboration. Most of the work related to the last two phases usually needs to be done as homework. At the end of semester the students gives the presentation of their project work, presenting the important steps and the final solution of the project (Fig.3).

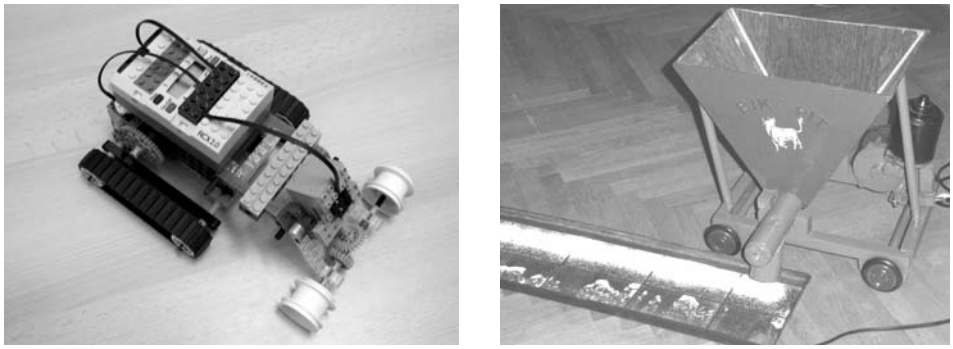

*Figure 3 Two final results of the projects*

## 6 CONCLUSIONS

For many years, the presented approach of design education is performed quite successful at our faculty. The success varies from year to year, from group to group. It depends on many circumstances and factors. However, in order to increase the success of the approach presented, some general guidelines can be derived from our experiences:

- members of the group and lecturer should friendly accept each other,
- the possibility to define their own project usually increases the students' motivation,
- project complexity should be extensive enough considering the number of group members,
- well defined reward (exam marks or payment) may increase the success,
- objective project examination also motivates the students,
- exact definition of millstones is essential,
- optimistic approach of all members and lecturer is required,
- sometimes an excursion related to the project adds new élan,
- financial support for project prototype improves the final result,
- it is a good idea to announce the competition and first place price.

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